(12) UK Patent Application (19) GB (11) 2 091 508 A

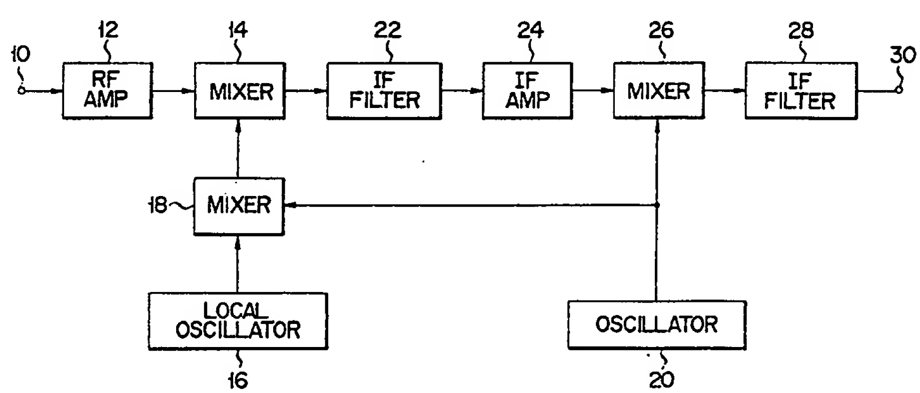
(21) Application No 8138978
(22) Date of filing 24 Dec 1981
(30) Priority data
(31) 55/184919
(32) 25 Dec 1980
(33) Japan (JP)
(43) Application published
28 Jul 1982
(51) INT CL[3]
H03D 7/16
(52) Domestic classification
H3Q DRD
H3T 1G3X 2B9 2Q 2T2X
2W2 2W3 3V 4E2N FA
(56) Documents cited
GB 1074755
GB 942373
GB 766074
GB 731715
GB 625358
GB 613902
GB 512253
(58) Field of search
H3A
H3F
H3Q
H3T

(71) Applicants
Tokyo Shibaura Denki
Kabushiki Kaisha,
72 Horikawa-cho, Saiwai-ku, Kawasaki-shi, Japan
(72) Inventor
Jyoji Nagai
(74) Agents
Marks & Clerk,
57—60 Lincoln's Inn
Fields, London WC2A 3LS

# (54) Double superhet tuner

(57) A tuner includes a first mixer (14) which converts an input radio frequency (RF) signal to a first intermediate frequency (IF) signal at a filter (22) using the output signal from a variable local oscillator (16) fed via a mixer (18) which is also supplied from a fixed frequency oscillator (20) and a second mixer (26) converts the first IF signal to a second IF signal at a filter (28) using the output signal from the oscillator (20), the second IF signal having a fixed frequency lower than the frequency of first IF signal. The frequency of oscillator (20) is lower than the lowest frequency of local oscillator (16). The oscillators 16 and 20 may each be a transistor (32, 70 Fig. 2) with a varactor diode (52) for tuning oscillator (16) and mixer (18) as a diode (64).

FIG. 1




GB 2 091 508 A

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

F I G. 1

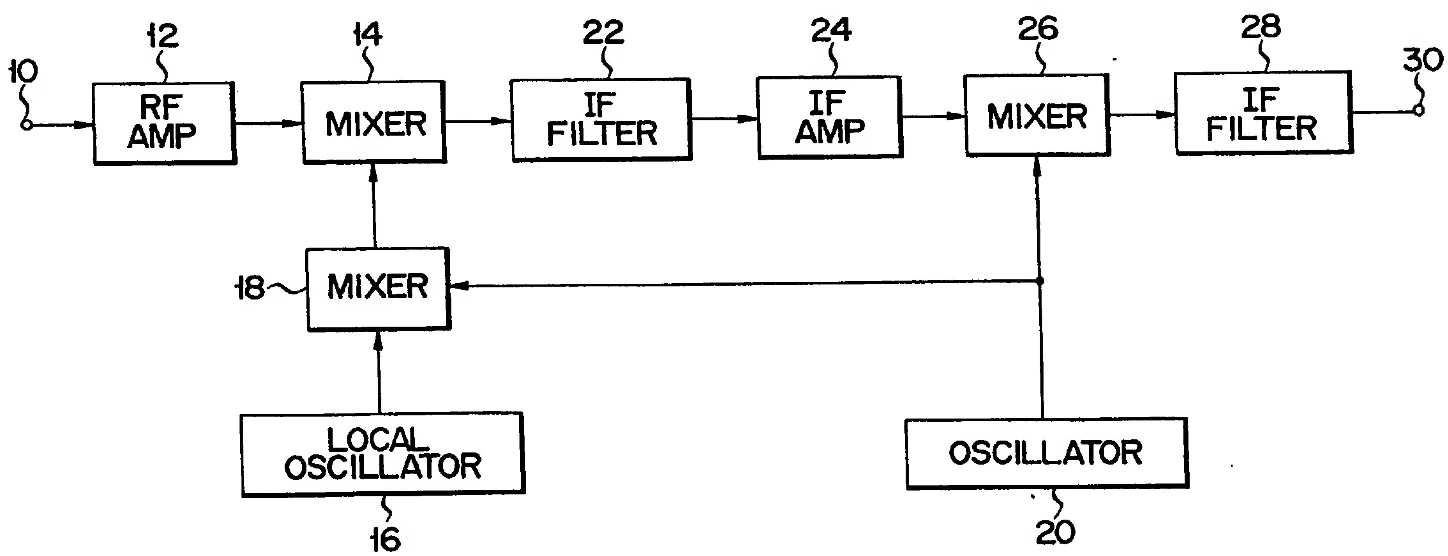
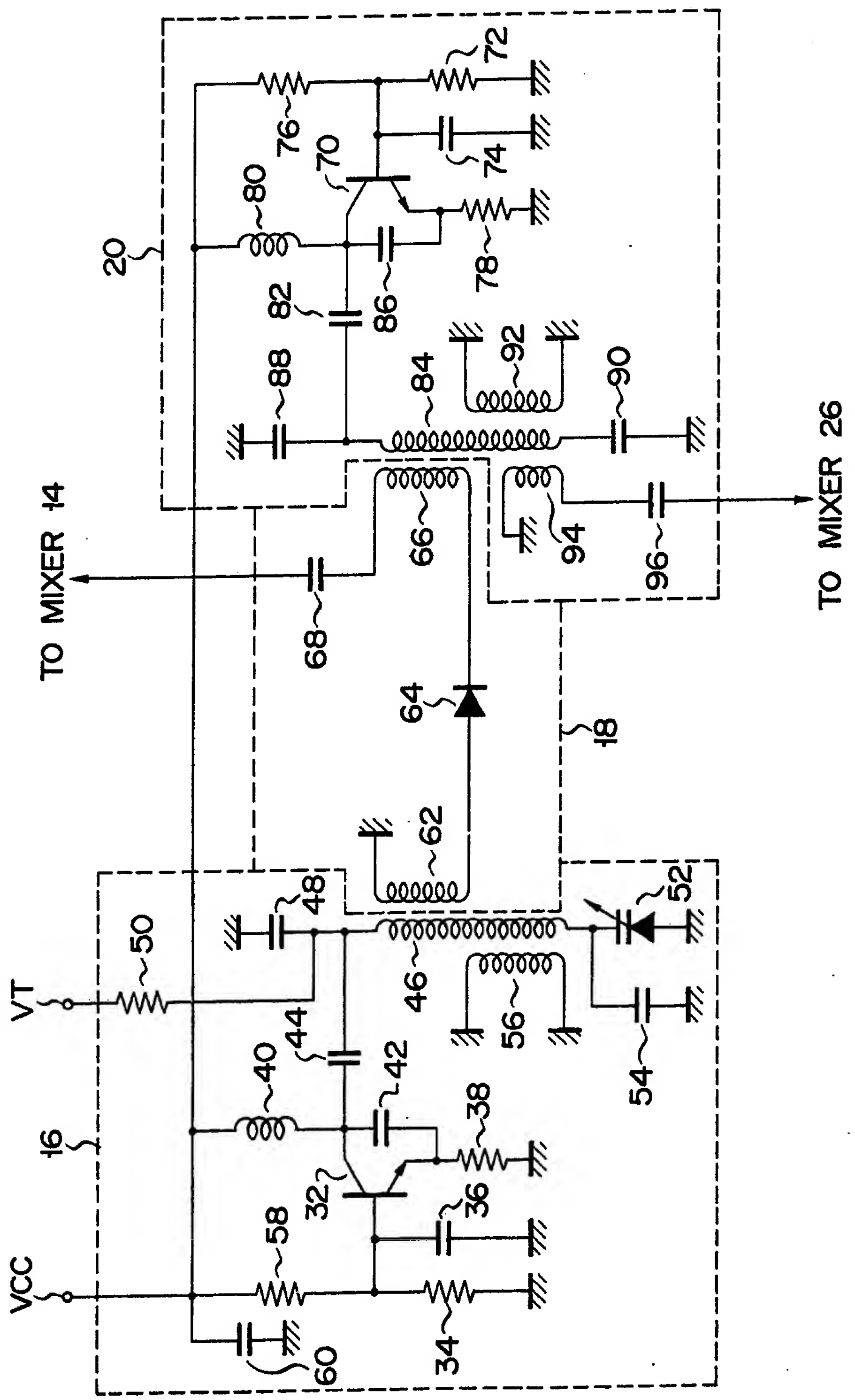

10
12
RF AMP
14
MIXER
22
IF FILTER
24
IF AMP
26
MIXER
28
IF FILTER
30
18
MIXER
LOCAL OSCILLATOR
16
OSCILLATOR
20

FIG. 2



SPECIFICATION

**Tuner**

The present invention relates to a tuner and, more particularly, a tuner capable of receiving input signals in a wide frequency range.

The well-known tuner usually employed in the television receiver is of single super heterodyne type including a mixer, a local oscillator and an intermediate frequency (IF) filter. A television signal excited by the antenna in the case of usual television broadcasting or supplied through the cable in the case of CATV broadcasting is supplied through the radio frequency (RF) amplifier to one input terminal of the mixer. On the other hand, a signal having a frequency according to the selected channel is supplied from the local oscillator to the other input terminal of the mixer. The mixer produces signals having frequencies corresponding to the sum and the difference of the frequencies of these two input signals. The IF filter is adapted to pick up either of the output signals produced from the mixer, that is, only the signal having a frequency corresponding to the difference of frequencies of these two input signals. Therefore, the IF signal of the television signal having the frequency according to the selected channel is passed through the IF filter. The frequency oscillated by the local oscillator has a frequency range corresponding to the frequency range of the input television signal.

The television broadcasting includes VHF, UHF and CATV broadcastings these days. VHF broadcasting is divided to a Low-band ranging from 2 channel to 6 channel and a High-band ranging from 7 channel to 13 channel. The Low-band has a frequency range of image carrier ranging from 55.25 MHz to 83.25 MHz and the High-band has a frequency range of video carrier ranging from 175.25 MHz to 211.25 MHz. UHF broadcasting includes 14 channel to 83 channel and has a frequency range from 471.25 to 885.25 MHz. CATV broadcasting band is divided to a Mid-band ranging from channel A to channel I, a Super-band ranging from channel J to channel W, and a Hyper-band ranging from channel X to channel M13 and has frequency ranges of 121.25 to 169.25 MHz at the Mid-band, 217.25 to 295.25 MHz at the Super-band, and 301.25 to 403.25 MHz at the Hyper-band. For the purpose of allowing a single set of tuner to receive all of television broadcastings, therefore, local oscillation frequency must be largely changed so as to be suitable for the input signal having frequencies in the wide frequency range of 55.25 to 403.25 MHz.

Providing that an inductance is represented by L, equivalent capacity CC, and a variable capacity CV, an oscillated-frequency f of an LC oscillating circuit is represented as follows:

$$f = \frac{1}{2\pi\sqrt{L(CV + CC)}} \quad \ldots\ldots (1)$$

wherein the inductance is connected parallel to the equivalent capacity CC and variable capacity CV. The equivalent capacity CC is a fixed one and represents the stray capacity of the circuit. Providing that maximum and minimum values of the variable capacity of the oscillating circuit are respectively represented by CVmax and CVmin, maximum and minimum values fmax and fmin of the oscillation frequency are obtained from equation (1) as follows:

$$fmax = \frac{1}{2\pi\sqrt{L(CVmin + CC)}} \quad \ldots\ldots (2)$$

$$fmax = \frac{1}{2\pi\sqrt{L(CVmax + CC)}} \quad \ldots\ldots (3)$$

From equations (2) and (3),

$$fmax/fmin = \sqrt{\frac{CVmax + CC}{CVmin + CC}} \quad \ldots\ldots (4)$$

It can be found therefore that the oscillation frequency changing ratio (fmax/fmin) of the oscillating circuit becomes larger as

$$\frac{CVmax + CC}{CVmin + CC}$$

becomes larger. The smaller the fixed capacity CC becomes, the larger the changing ratio becomes.

However, the changing ratio of capacity of the variable capacity element, e.g., varactor diode now practically employed is not so large. This changing ratio (CVmax/CVmin) is about 5.0 in the case of average products and reaches only about 9.7 even in the case of products having a widely changing ratio. Providing that CC is 3pF, therefore, the oscillation frequency changing ratio obtained from equation (4) is 1.65 in the case of average products and reaches only about 2.31 in the case of products having a widely changing ratio. When the IF signal is at 45.75 MHz as in U.S.A. (58.75 MHz in Japan and 38.75 MHz in West Germany), therefore, local oscillation frequency must be changed over a range of 101 to 931 MHz to generate an IF signal which corresponds to the difference in frequency between the input signal of 55.25 to 885.25 MHz and local oscillation signal. The oscillation frequency ratio becomes about 9 in this case and such local oscillation signal can not be generated by a single local oscillator. Therefore, exclusive tuners are respectively arranged for VHF, UHF and CATV. The inductance in the oscillating circuit is changed over every band of each of VHF, UHF and CATV (Low and High-bands of VHF, UHF band, Mid, Super and Hyper-bands of CATV). When such arrangement is employed, however, the device must be made large-sized and the circuit thereof becomes complicated in construction because a changeover section is

needed.

To eliminate these drawbacks is considered these days a tuner of double super heterodyne type in which two single super heterodyne tuners are connected in series to each other. One of local oscillators is variable in oscillation frequency and the other is fixed in oscillation frequency. A first local oscillator connected on the input side is usually variable in oscillation frequency. The television signal and output signal from the first local oscillator are mixed in a first mixer, and the first mixer and a first IF filter connected to the output terminal of the first mixer generate a first IF signal having a fixed frequency higher than that of the usual IF signal. The first IF signal and output signal from the second local oscillator having a fixed oscillation frequency are mixed in a second mixer, and the second mixer and a second IF filter connected to the output terminal of the second mixer generate a second IF signal which corresponds to the usual IF signal. Namely, since the first IF signal has frequency higher than that of the usual IF signal, the oscillation frequency of the first local oscillator is ranged in a high frequency band. When the frequency band is high, the range in which the frequency is changed become wide even if the changing ratio of the oscillation frequency is same. Providing that the first IF signal is at 3GHz, for example, the first local oscillation frequency may be changed over a range of 3055.25 to 3885.25 MHz. The changing ratio of the oscillation frequency is about 1.3 in this case and even a single tuner can cover all of the television broadcastings enough.

However, what the first intermediate frequency is set high means that the center frequency of the first IF filter is made high. When the center frequency is high, Q must be made large to make the characteristic of the filter sharp, but the extent to which Q is made large is limited. When the center frequency becomes about 3GHz, therefore, only a filter having bad selecting characteristic can be realized, thus causing unnecessary broadcasting signals of adjacent channels to be received. Practically, the output signal of the first IF filter is supplied through an IF amplifier to the second mixer. However, when the first intermediate frequency is high, the gain of this IF amplifier is small to finally deteriorate the S/N ratio of the whole tuner. On the contrary, when the first intermediate frequency is made low, the first local oscillation frequency becomes low, thus making it impossible for a single tuner to receive all of television broadcasting bands.

In contrast to the above, a tuner of double super heterodyne type in which the first local oscillator is fixed in frequency and the second local oscillator is variable in frequency is considered. However, center frequency of the first IF filter must be changed to a frequency corresponding to the selected channel in this case, and it is also difficult to realize such filter.

The object of the present invention is to provide a tuner capable of receiving signals in a wide frequency range using a single variable frequency oscillator.

This object of the present invention can be achieved by a tuner comprising a first oscillator whose oscillation frequency is variable, a second oscillator for oscillating a first fixed frequency lower than the lowest frequency oscillated from the first oscillator, a mixer for heterodyning the output signal from the first and second oscillators, a first frequency converter for converting a radio frequency input signal to a signal having a second fixed frequency using the output signal from the mixer, and a second frequency converter for converting the output signal from the first frequency converter to an intermediate frequency signal having a fixed frequency lower than the second fixed frequency using the output signal from the second oscillator.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram showing an embodiment of a tuner according to the present invention; and

Fig. 2 is a circuit diagram showing in detail the main portion of the tuner shown in Fig. 1.

An embodiment of a tuner according to the present invention will be now described referring to the drawings. In Fig. 1, an input terminal 10 coupled to an antenna or a cable line of CATV (not shown) is connected to an input terminal of an RF amplifier 12, whose output terminal is connected to a first input terminal of a mixer 14. An output terminal of a local oscillator 16 whose oscillation frequency is variable is connected to a first input terminal of a mixer 18, whose output terminal is connected to a second input terminal of the mixer 14. The oscillation frequency of the local oscillator 16 is set higher than in the usual tuner of single super heterodyne type so as to enable the range of the frequency change to become wide even if the frequency changing ratio is small. An output terminal of an oscillator 20 whose oscillation frequency is fixed is connected to a second input terminal of the mixer 18. The mixers 14 and 18 heterodyne first and second input signals to produce two signals having frequencies which correspond to the sum and the difference of frequencies of the first and second input signals. Providing that the difference signal is produced from the mixer 18, the oscillation frequency of the local oscillator 16 can be set higher by the oscillation frequency of the oscillator 20 as compared with the conventional tuner of double super heterodyne type without setting the first intermediate frequency high. An output signal of the mixer 14 is supplied to a first input terminal of a mixer 26 through an IF filter 22 and IF amplifier 24 in series. The IF filter 22 is a band pass filter which allows only a first IF signal having a frequency higher than that of the usual IF signal to pass therethrough. Namely, the mixer 14 and IF filter 22 serve as a first frequency converter for converting the input RF signal to the first IF signal. Since the center frequency of the IF filter 22 is

high, a surface acoustic wave filter is used as the IF filter 22. However, the first intermediate frequency in this embodiment is lower than that in the conventional tuner of double super heterodyne type so that Q of the IF filter 22 can be realized. An output signal of the oscillator 20 is supplied to a second input terminal of the mixer 26. Similar to the mixers 14 and 18, the mixer 26 also produces two signals having frequencies which corresponds to the sum and the difference of frequencies of both input signals. An output signal of the mixer 26 is supplied through an IF filter 28 to an output terminal 30. The IF filter 28 is also a band pass filter which allows only a second IF signal, i.e., the usual IF signal to pass therethrough. The mixer 26 and IF filter 28 serve as a second frequency converter for converting the first IF signal to the second IF signal.

The operation of this embodiment will be now described. The oscillation frequency of the local oscillator 16 is set to a frequency corresponding to the selected channel. Providing that the local oscillation frequency changes from F1min to F1max and that the oscillation frequency of the oscillator 20 is F2 (F2 < F1min), the output frequency of the mixer 18 changes as follows: suffixes "max" and "min" appended to each of frequencies represent maximum and minimum values, respectively. The difference signal F3 changes from F3min (= F1min − F2) to F3max (= F1max − F2) and sum signal F3′ from F3′min (= F1min + F2) to F3′max (= F1max + F2). Since the output signal of the mixer 18 is further mixed with the input RF signal by the mixer 14, the frequency F4 of the output signal from the mixer 14 is expressed as follows, providing that frequency of the input RF signal is Fin. The difference signal F4 is F3 − Fin or F3′− Fin and sum signal F4′ is F3 + Fin or F3′ + Fin. Since the frequency F3 or F3′ of the output signal from the mixer 18 has changed corresponding to the selected channel, the output frequency F4 or F4′ of the mixer 14 can be always made constant independently of the selected channel. The IF filter 22, easily manufactured, allows only the difference signal (F4 = F3 − Fin) of the output signals of the mixer 14 to pass therethrough and prohibits the sum signal (F4′ = F3 + Fin) and unnecessary signals, e.g., signals of adjacent channels supplied to the IF filter 22 to pass therethrough. The output signal of the IF filter 22 thus becomes the first IF signal having the frequency F4. Even if the local oscillation frequency F1 is set high, the frequency F4 can be set low because the frequency F3 participating the first IF signal is lower by F2 than F1. The IF filter 22 can therefore have sharp characteristic without making Q so large and the unnecessary signal can be prevented from passing through the IF filter 22. The output signal of the IF filter 22 is supplied through the IF amplifier 24 to the mixer 26 and mixed there with the output signal of the oscillator 20. Namely, the output signal of the mixer becomes the differential signal F5 = F4 − F2 or sum signal F5′ = F4 + F2. As the reason will be described later, the IF filter 28 allows only the difference signal F5 = F4 − F2 to pass therethrough. The signal of frequency F5 produced from this IF filter 28 becomes the second IF signal, i.e., usual IF signal, which is supplied through the output terminal 30 to an video detector circuit (not shown).

Description will be now made representing frequency by a practical value in each of sections. Frequencies of the input RF signal and second IF signal are determined of themselves. It is imagined in this case that all of TV broadcasting such as VHF, UHF and CATV are received. Therefore, the frequency Fin of the input RF signal ranges from 55.25 MHz to 885.25 MHz and the frequency F5 of the second IF signal is 45.75 MHz. The frequency of the first IF signal, i.e., frequency F4 passing through the IF filter 22 is set 450 MHz so as to allow the SAW filter to have characteristic sharp enough. Since F2 = F4 − F5, the oscillation frequency F2 of the oscillator 20 is set 404.25 MHz. The mixer 14 mixes the input RF signal with the output signal of the mixer 18 and the difference signal of 450 MHz is extracted from the output sum and difference signals of this mixer 14 by the IF filter 22. Therefore, the output frequency F3 of the mixer 18 ranges from 505.25 MHz to 1335.25 MHz. Since the output frequency F3 of the mixer 18 ranges from 505.25 MHz to 1335.25 MHz, the frequency F1 of the output signal from the local oscillator 16 which is mixed with the oscillation signal from the oscillator 20 by the mixer 18 may range from 909.5 MHz to 1739.5 MHz (the mixer 18 takes up the difference and produces the signal of 505.25 to 1335.25 MHz (= F3)) or from 101 MHz to 931 MHz (the mixer 18 takes up the sum and produces the signal of 505.25 to 1335.25 MHz (= F3′)). In the case of the latter, the frequency changing ratio reaches almost 9 and the local oscillation signal can not be generated by means of a single variable capacity element. In the case of the former, however, the frequency changing ratio is about 1.9 because the frequency is high, and the local oscillator 16 can be therefore realized using a single variable capacity element now available.

As described above, the output signal of the local oscillator 16 is converted, using the output signal of the oscillator 20 having the fixed frequency, to the signal of the lower frequency by means of the mixer 18, and the input RF signal is converted, using the output signal of this mixer 18, to the first IF signal by means of the mixer 14 and IF filter 22. This enables the oscillation frequency of the local oscillator 16 to be made high and the local oscillation signal capable of processing the input RF signal in a wide frequency range can be obtained even if the capacity ratio, i.e., oscillation frequency changing ratio of the local oscillator is small. In addition, the first intermediate frequency may not be set so high. The IF filter 22 having sharp characteristic can be therefore realized, thus preventing signals except that of the selected channel, i.e., signals of the adjacent channels and those having other beat

frequencies from passing therethrough. This enables a single set of tuner (or signal variable oscillator) to receive all of TV broadcastings.

Fig. 2 is a circuit diagram showing more concretely the local oscillator 16, mixer 18 and oscillator 20.

In the local oscillator 16, a base of an NPN transistor 32 is grounded through a resistor 34 and capacitor 36 in parallel, the emitter thereof is also grounded through a resistor 38, and collector thereof is connected through an inductor 40 to a power source terminal VCC. A capacitor 42 is connected between the emitter and collector of the transistor 32, whose collector is connected through a capacitor 44 to one end of an inductor 46 which serves as a resonance element. The one end of the inductor 46 is grounded through a capacitor 48 and connected through a resistor 50 to a turning power source terminal VT. The other end of the inductor 46 is connected to a cathode of a varactor diode 52, which serves to make frequency variable, while grounded through a capacitor 54. An anode of the varactor diode 52 is grounded. An inductor 56 whose both ends are grounded and which serves to perform fine-adjustment is arranged adjacent to the inductor 46 and the distance between the inductors 56 and 46 is made variable. The base of the transistor 32 is connected through a resistor 58 to the power source terminal VCC, which is grounded through a capacitor 60.

In the mixer 18, a coupling inductor 62 whose one end is grounded is arranged adjacent to the inductor 46 in the local oscillator 16. The other end of the inductor 62 is connected to an anode of a mixing diode 64, whose cathode is connected through a coupling inductor 66 and capacitor 68 to the mixer 14.

In the oscillator 20, a base of an NPN transistor 70 is grounded through a resistor 72 and capacitor 74 in parallel and connected through a resistor 76 to the power source terminal VCC. An emitter of the transistor 70 is grounded through a resistor 78 and a collector thereof is connected through an inductor 80 to the power source terminal VCC while through a capacitor 82 to one end of an inductor 84, which serves as a resonance element. A capacitor 86 is connected between the emitter and collector of the transistor 70. The inductor 84 is arranged adjacent to the inductor 66 in the mixer 18 with its one end grounded through a capacitor 88 and with its other end grounded through a resonance capacitor 90. A fine-adjusting inductor 92 whose both ends are grounded is arranged adjacent to the inductor 84 and the distance between the inductors 84 and 92 is variable. An inductor 94 whose one end is grounded and whose other end is connected through a coupling capacitor 96 to the mixer 26 is also arranged adjacent to the inductor 84.

In the case of tuner having the arrangement as described above, the varactor diode 52 is under reverse bias condition. Therefore, the capacity of the varactor diode 52 changes responsive to the voltage appearing at the power source terminal VT and the resonance frequency of the resonance circuit comprising the inductor 46, varactor diode 52 and capacitor 54 changes accordingly. In addition, this resonance frequency is fine-adjusted by changing the distance between the inductors 46 and 56. The oscillation signal flowing through the inductor 46 is transmitted through the coupling inductor 62 to the diode 64.

The oscillator 20 has a fixed capacity 90 and therefore oscillates at a fixed frequency. The oscillation frequency is also fine-adjusted by changing the distance between the inductors 84 and 92. The oscillation signal flowing through the inductor 84 is transmitted through the coupling inductor 66 to the mixer 18 while through the coupling inductor 94 and capacitor 96 to the mixer 26.

It should be understood that the present invention is not limited to the above-described embodiment and that various changes and modifications can be made without departing from the scope of the present invention. In short, the gist of the present invention resides in that, using a signal generated by mixing the output of the local oscillator whose oscillation frequency is variable with the output signal of the oscillator whose oscillation frequency is fixed, an input RF signal is converted to the first IF signal having a fixed frequency higher than that of the usual IF signal.

CLAIMS

1. A tuner comprising:

a signal input terminal to which a radio frequency signal is supplied;

first oscillating means whose oscillation frequency is variable;

second oscillating means whose oscillation frequency is fixed and lower than the lowest frequency of the oscillation frequencies by said first oscillating means;

mixer means for heterodyning the output signals of said first and second oscillating means;

first frequency converting means for converting, using the output signal of said mixer means, the radio frequency signal supplied to said signal input terminal to a first intermediate frequency signal having a fixed frequency; and

second frequency converting means for converting, using the output signal of said second oscillating means, the output signal of said first frequency converting means to a second intermediate frequency signal having a fixed frequency lower than the frequency of said first intermediate frequency signal.

2. A tuner according to claim 1, wherein said first frequency converting means includes a mixer whose first and second input terminals are respectively coupled to said signal input terminal and the output terminal of said mixer means and which produces signals having frequencies corresponding to the sum and the difference of the frequencies of first and second input signals, and a filter coupled to the output terminal of said mixer and serving to extract only said first intermediate

frequency signal, and said second frequency converting means includes a mixer whose first and second input terminals are respectively connected to said filter and second oscillating means and which produces signals having frequencies corresponding to the sum and the difference of the frequencies of first and second input signals, and a filter coupled to the output terminal of said mixer and serving to extract only said second intermediate frequency signal.

3. A tuner according to claim 2, wherein said filter in said first frequency converting means is of surface acoustic wave type.

4. A tuner according to claim 1 or 2, wherein said signal input terminal is coupled through a radio frequency amplifier to said first frequency converting means, and said first frequency converting means is coupled through an intermediate frequency amplifier to said second frequency converting means.

5. A tuner, substantially as hereinbefore described with reference to the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1982. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.